

CIRCULAR No. 120

(SEPTEMBER, 1914)

POTATO GROWING IN THE SAN JOAQUIN AND SACRAMENTO DELTAS OF CALIFORNIA

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INTRODUCTION

The delta lands of the San Joaquin and Sacramento rivers occupy an area of about 250,000 acres of very fertile peat soil. They lie at about sea level and for the most part consist of a peat formation made up of more or less incompletely decomposed roots and stems of tule and other marsh plants, to which has been added the sediment deposited by the rivers. The depth of the peat and the amount of sediment varies considerably in different localities. Before these lands were reclaimed they were flooded during the major portion of the year. The marshes are reclaimed by throwing up levees along the rivers or sloughs to exclude tidal and flood waters, while by means of ditches and pumps the water is kept at a sufficiently low level to permit the growing of many farm crops. The additional water needed for irrigation during the summer months is brought over the levees by means of siphons, or through the levees by the use of headgates. The rainfall of this section of the state averages about 15 inches per year, the rainy season beginning in October and ending in April.

The principal crops grown in the region are potatoes, barley, beans, and onions. A considerable acreage has been planted to asparagus, but the area devoted to this crop is becoming more restricted than heretofore. Celery is also grown to some extent. The principal cash crop, however, is potatoes and an area of from forty to fifty thousand acres is annually devoted to this crop.

GENERAL PRACTICES IN HANDLING THE POTATO CROP

During the first three years following the reclamation of these lands they are cropped every year to potatoes. Afterwards the prin-

cipal rotation, especially in the San Joaquin portion of the delta, consists of barley alternated with potatoes until, owing to the great reduction in the yields, it becomes no longer profitable to grow potatoes. During the first year or two the yields often run from 200 to 300 sacks per acre (350-550 bushels). At the end of eleven years (and this system of rotation is sometimes persisted in for that length of time) the land has been seven times planted to potatoes and the yields run as low as 35 sacks per acre. The farmers are usually annual tenants, the potato growers moving each year from farm to farm and growing no crop save potatoes. The potato farm usually comprises an area of from 150 to 300 acres, while the barley farm is a combination of several of the farms planted to potatoes the preceding year.

Potato planting covers the period from March to June, and sometimes extends into July. The Burbank potato, a rather late variety, is grown almost universally, although often a small quantity of an early variety is planted first in order that the harvesting of the early crop may begin almost as soon as the late planting is completed. The land is usually plowed early in the year and again at planting time, the seed pieces being dropped by hand in the furrows behind the plow at every other round, this bringing the rows about 30 inches apart. To keep down the weeds the ground is harrowed two or three times before the young plants get far above the surface. After this the crop is given from one to three cultivations, is hand hoed once or twice and is then ridged.

The harvesting is done by hand with the aid of potato hooks, the marketable tubers being picked into baskets as dug and then sacked in the field, the cull potatoes being left on the ground. The potatoes required for seed purposes the following year are usually harvested in December and stored in sacks or in bulk in large piles on the levees. Often the only protection given this seed stock is a covering of tule stalks or a more or less open shed. (See fig. 1.)



Fig. 1.—Seed potatoes stored on the levee and sprouting badly.

THE WEAK POINTS IN THIS SYSTEM AND THEIR RELATION TO LOW
YIELDS

Owing to the fact that experiments are now being conducted to determine the best cultural methods for use in the delta section, a discussion of this feature of potato growing will be postponed until some definite results have been obtained. The principal object of this paper is to call to the attention of the farmers and owners of lands in this and other sections of the state where similar conditions exist the great importance of making certain changes in their methods of handling the potato crop. Experience has already shown it to be imperative that such changes should be made if the industry is to continue to thrive.

Storage of Seed.—Owing to the large acreage devoted to potatoes by the individual growers and to the slow method of planting, with the consequent lengthy period needed for this work, the seed stock under present conditions of storage becomes badly sprouted long before planting is finished. The sprouts often grow from 12 to 18 inches and the tubers become much softened. This sprouting uses up large quantities of the food material stored in the potatoes which should go to feed the young plants in the field; moreover, when the sprouts are broken off and the tubers cut up and planted many of the small pieces fail to sprout again and there is a consequent poor stand over the field. The pieces which do sprout produce weak plants, which are easily affected by disease or other unfavorable conditions of growth, such as cold weather or too much or too little moisture, and the yield is consequently reduced.

A great improvement in the condition of seed stock could be brought about by the construction of a simple type of frame storage building with double walls filled with some cheap material such as barley straw. The night temperatures throughout the spring often run as low as 40 degrees, and by the use of ventilators at the top and bottom of the building, which could be opened at night to admit the cold air and closed in the morning to shut out the warm air, sufficiently low temperatures might be maintained to greatly retard the sprouting of the potatoes. The best temperature for the storage of potatoes is from 36 to 40 degrees F., but they will not sprout for a considerable length of time under slightly warmer conditions.

Influence of Cull Potatoes and Short Rotation.—Another practice which is indirectly responsible for the decreasing yields of potatoes on the delta lands is that of leaving the cull potatoes scattered over the fields at the time of harvesting. One could scarcely devise a better

method for spreading the diseases which are now playing great havoc with the potato industry. It can hardly be considered a rotation to grow potatoes for three successive years after the reclamation of these lands, and then every other year thereafter. Owing to the mild winters in the delta, the cull potatoes produce a large volunteer crop, and the preparation of the soil for the barley crop does not kill out the potato plants; hence they form an almost continuous growth upon the land from year to year. In this way all of the diseases which affect potatoes, once introduced on the seed tubers, are afforded ample opportunity of living over in the soil and of increasing with great rapidity. The custom in vogue on the islands of having annual tenants who move from camp to camp every year, carrying their seed potatoes with them, provides the means for the general distribution of all the potato diseases.

DISEASES DIRECTLY RESPONSIBLE FOR DECREASED YIELDS

Rhizoctonia.—There are several potato diseases which have become very widespread throughout the delta. The one which at present is probably responsible for the greatest injury to the crops is *Rhizoctonia*. This is a fungous disease which lives over from year to year on stored potatoes and also in the soil on roots of various plants. The accompanying photograph (fig. 2) shows its appearance upon the potato.



Fig. 2.—*Rhizoctonia* on potato tuber. (After Orton, Bureau of Plant Industry, U. S. Department of Agriculture.)

It looks very innocent upon the tubers and does not usually injure them for domestic purposes. It is likely to pass unnoticed by the average grower since it cannot easily be detected when the potatoes are more or less covered with soil. The difficulty with which it can be removed by rubbing or washing presents about the only test by which it can be distinguished from the soil on the tuber. When conditions are favorable for the sprouting of the tubers the fungus

spreads among them rapidly, and after the potatoes are planted it attacks the young shoots as they develop, often girdling and cutting off the smaller ones and more or less seriously injuring the larger ones. When the underground stolons, which are formed to produce

the young potatoes develop, the fungus also attacks them and prevents the formation of tubers. If an examination is made of the growing plants in almost any field many of them are likely to be found in the condition of the plant shown in the accompanying photograph (fig. 3).

A very conservative estimate of the amount of damage done by this disease during the season of 1913 would place the average loss throughout the delta region at 25 per cent, or an actual financial decrease of a million dollars in the value of the crop.

This disease lives on many other cultivated plants, especially legumes, and the only practical method which can at present be recommended for getting it

out of the soil is a long rotation of crops upon which it does not thrive. After it is once starved out of the soil, disease-free seed should be planted.

Wilt Diseases.—Two species of fungi (*Fusarium oxysporum* Schleet. and *Verticillium albo-atrum* Reink. and Berth.) are very common upon the potatoes grown in the delta. Both of these diseases produce a discoloration of the stems and tubers a short distance beneath the surface of the ground. This discoloration in the tubers forms a more or less incomplete ring in the vascular portion of the potato as shown in the accompanying photograph (fig. 4). It is most prominent at the stem end and disappears more or less gradually, depending upon the severity of the attack, toward the opposite end of the tuber. This disease causes a wilting of the growing plants, due to the fact that the growth of the fungus in the stems cuts off the supply of water from the roots. It becomes much more noticeable



Fig. 3.—Potato stems affected with *Rhizoctonia*.

toward the end of the growing season and on the drier portions of the fields. A serious feature of this disease is that it forms a means of entrance for other fungous and bacterial diseases of the tubers such as "jelly end" and dry rot, which are also very destructive in many places.

The wilt diseases are introduced into the soil through diseased seed tubers, and no potatoes showing a discoloration near the stem end such as is shown in the cut (see fig. 4) should be used for seed purposes. A long rotation and the use of disease-free seed are the only recommendations that can be made for the control of these diseases.



Fig. 4.—Potato tubers affected with wilt. (After Orton, Bureau of Plant Industry, U. S. Department of Agriculture.)

Scab.—This is a disease that is well known to all the potato growers of the delta, and in some localities and under certain conditions it causes considerable loss throughout the section. It is introduced through the use of diseased seed tubers and becomes much worse on alkali soil than elsewhere.

Tubers affected by scab should either be treated by soaking for two hours in a solution of formaldehyde (one pint to 30 gallons of water), or else not used for seed purposes. The infection is likely to be present in such a small amount as to be unnoticeable and great care should be exercised to plant clean seed. The treatment of seed potatoes with formaldehyde is not advisable if the tubers have sprouted badly, as a poor stand is likely to result from its use. Moreover, this treatment is not alone sufficient to prevent infection of the crop if the soil has already been infected. It is necessary to practice a long rotation to remove the disease from the soil after it has once gained a foothold.

Tuber Moth.—For some reason, probably because of the large amount of water used for irrigation in this locality, the tuber moth (*Phthorimaca operculella* Zell.) has not thus far caused very serious damage to potatoes in the soil before harvesting. This is true, at least, for the peat soils which are kept well watered, although on higher land the moth has sometimes proved quite injurious. Conditions may arise, however, under which this pest may become more generally serious, and it is advisable to prevent its multiplication as far as is possible. Potatoes examined by the writer as they were being dug from a typical moist, peat soil showed but one or two per

cent of tuber moth infestation. Several days later, however, an examination of the cull tubers which had been left upon the ground in the same field showed that 90 per cent of them were infested with this pest. This indicates how rapidly the moths are multiplied through the practice of leaving cull potatoes upon the ground. The moth also attacks potatoes in sacks, and great care should be taken to keep all marketable stock well covered so that the moth cannot gain access. (See fig. 5.)

The Nematode Gallworm or Eelworm.—This disease of potatoes and of many other crops is caused by a minute nematode worm (*Heterodera radicum* (Greef.) Müll.). While it has not thus far become widely prevalent in the delta as a serious pest on potatoes, it is known to be present in certain fields in this locality and has caused much trouble in other parts of the country and in the old world. The accompanying photographs (figs. 6 and 7) shows the appearance of tubers infested with this parasite. It may be present in many tubers in such small quantities as to render it difficult of detection and may become widespread through the planting of infested potatoes. All potato growers

should be very careful that their seed is absolutely free from this pest. It is also of especial importance to the landowners to keep their soil free from such infestation, since its eradication when once it is introduced is a very difficult task.

All seed potatoes should be carefully inspected by some one who is familiar with this trouble and no seed stock should be planted about which there is any suspicion as to the presence of the parasite. Before buying potatoes for seed purposes planters should make sure that the locality in which they were grown is not infested.

The nematode worm thrives on a large number of cultivated plants, which fact makes it all the more important that every precaution should be used to keep the land free. It should not be taken for granted that conditions in the delta are unfavorable for the spread of this trouble and every effort should be made to restrict its distribution. After once being introduced into the soil it is very easily



Fig. 5.—Potato showing comparatively light injury from the potato tuber moth (*Phthorimaca operculella*). (After Chittenden, Bureau of Entomology, U. S. Department of Agriculture.)

carried into other fields, either on the roots of plants or in the soil on boots and farm implements, or in irrigation water. It is all the more dangerous because of the fact that it attacks a great variety of farm

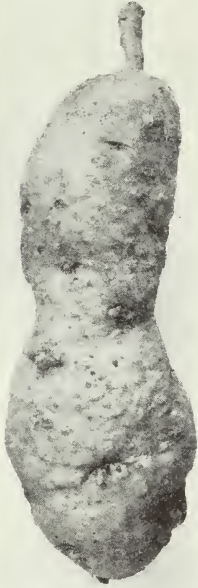


Fig. 6

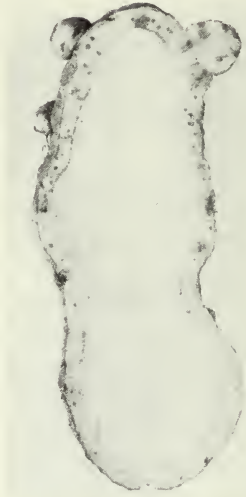


Fig. 7

Potato infested with celworms. (After Orton, Bureau of Plant Industry, U. S. Department of Agriculture.)

crops and weeds, including crops now grown in the delta such as onions, beans, celery, and alfalfa. It is very difficult to eradicate completely the nematode after it has once become well established in the soil, but it is possible to reduce the amount of infestation by growing crops upon which it does not thrive. Some of the crops which are little or not at all affected by this parasite are barley, sorghum, milo, timothy, redtop, and oats.

GENERAL RECOMMENDATIONS

Since all of the diseases which affect the potatoes of the delta have, without much doubt, been introduced by planting infected seed, it is evident that they cannot be eradicated so long as diseased seed stock is used. To eradicate any or all of these diseases from soil

already infected it is necessary that the cull potatoes be removed from the field at the time the marketable tubers are harvested. This will not be a great hardship to the grower, as the expense of gathering the cull potatoes into separate baskets at the time the others are picked up will not be great. Moreover, the cull potatoes are valuable for stock feeding purposes, and this economy more than offsets the expense of picking them up. They make an excellent food for hogs, especially when cooked and fed with corn or other grain. Horses also eat considerable quantities of them with relish. Besides, even if these cull potatoes cannot be used for feeding stock, it will be an expenditure well worth while for the landowners to have them taken off the fields in order to reduce the size of the volunteer crop and prevent the spread and multiplication of the diseases mentioned above.

Since it usually takes two years to get rid of the volunteer potatoes even when other crops are grown following the potato crop, a rotation shorter by one or two years will produce as good results as a correspondingly longer rotation under the present system. After the infected fields are freed from volunteer potatoes and before good crops of marketable potatoes can be produced it will be necessary to carry a rotation of other crops for several years in order to starve the diseases out of the soil.

The experience which owners and tenants have had with potatoes on the older reclaimed areas should impress the owners of the new areas and their tenants with the desirability of keeping the new land as far as possible free from potato disease. This can only be accomplished by rigidly inspecting the seed potatoes and discarding all diseased stock. It is a difficult matter at the present time to obtain seed potatoes which are not affected with one or more of the diseases mentioned. Every effort should be made, however, to secure the best possible seed, even though this is more expensive than the ordinary stock.

Many of these diseases are so widespread over the country that it would be advisable for the growers to co-operate in securing some locality where the soil has not yet become inoculated and where disease-free seed potatoes may be grown. If the tenants are not willing to do this, it would be to the interest of the landowners to secure disease-free seed stock and stipulate that the tenants plant only such seed as the owners furnish.

The seed potatoes for the delta come originally from Oregon or other nearby states, the growers planting a small amount of this seed every year to furnish seed stock for the general crop the following year. The prevailing opinion is that while this seed does not yield

as well during the first year as does the home-grown seed, yet the latter stock must be renewed every other year. In other words, the growers believe that potatoes grown in the delta two or more seasons lose their vitality to such an extent as to make it advisable to get a new stock from another locality. Whether this view of the situation is correct needs to be demonstrated by careful experimentation.

In whatever locality the seed potatoes are grown, they should be selected for productiveness and freedom from disease. Trained men are required to handle this work successfully, and growers should not be averse to paying a higher price for good seed stock than for the miscellaneous product now upon the markets. With potatoes, as with other crops, it is of prime importance that good seed stock be used, since only in this way can permanent success be obtained.

CROPS SUITABLE FOR ROTATION WITH POTATOES

Alfalfa has usually been considered a good crop to use in any rotation where potatoes are grown. Its use, however, has become questionable owing to the fact that *Rhizoctonia* may be carried over to the potato crop on the roots of alfalfa. This is equally true of other leguminous crops such as peas, beans, and clovers. The legumes are also infested with eelworm when the soil in which they are planted contains this parasite.

The crops which are least likely to carry any of the potato diseases are barley, oats, corn, buckwheat, broomcorn, rye grass, hemp, and celery. Onions are affected with *Fusarium*, and it has been noticed that "jelly end" is worse on potatoes following onions than elsewhere.

SUMMARY

The use of badly sprouted seed potatoes causes a considerable decrease in stand and yield.

Potato diseases are causing the growers immense losses every year.

Cull potatoes are responsible in large measure for the rapid increase of all potato diseases, and should therefore be removed from the fields at harvest time.

The short rotation system practiced in the delta is an important factor in the rapid distribution of potato diseases.

Long rotations of certain crops and the use of disease-free seed potatoes are the means which should be adopted to overcome the diseases and increase the yields.

The following publications will be found of value to those desiring further information concerning potato growing:

Farmers' Bulletin, No. 544, Potato Tuber Diseases.

Bureau of Plant Industry, Circular No. 23, Potato Diseases in San Joaquin County, California.

Bureau of Plant Industry, Circular No. 91, The Nematode Gallworm on Potatoes and Other Crop Plants in Nevada.

Farmers' Bulletin, No. 533, Good Seed Potatoes and How to Produce Them.

All of these publications can be obtained from the Secretary of Agriculture, Washington, D. C.

